REMARKS

This paper is in response to the Office Action mailed March 22, 2005. By this paper, claims 7-9 are amended and claims 10-16 are added. Accordingly, claims 1-16 are pending upon entry of this amendment.

Response to Rejection of Claim 1

Claim 1 is directed to a physical vapor deposition (PVD) method for deposition of dielectric materials, including low dielectric constant (low-k) materials, onto substrates during the fabrication of integrated circuits and other electronic, opto-electronic, microwave, and micro electro-mechanical (MEM) devices. More particularly, claim 1, is directed to a method for the physical vapor deposition of dielectric material onto a substrate comprising, *inter alia*:

> forming an energized monochromatic ion beam;
> converting said ion beam into an energized monochromatic beam of neutrals;
> directing said beam of neutrals toward a sputtering target;
> exposing said target to bombardment by said beam of neutrals;
> sputtering particles from said target;
> forming a cloud of said sputtered particles proximate to a substrate; and
> depositing said sputtered particles onto said substrate

Claim 1 in the application stands rejected as being anticipated by Katsube et al. (U.S. Patent No. 5,292,122). Applicant respectfully traverses this rejection. Claim 1 is novel and patentable over the references of record, and particularly over Katsube et al., because the cited art does not show or suggest a method for the physical vapor deposition of dielectric material onto a substrate comprising forming a cloud of sputtered particles proximate to a substrate as required by claim 1.

Katsube et al. discloses a method of forming a hydrophobic film on a substrate by irradiating a target consisting of a hydrophobic compound with a neutral atom beam and thereby

effecting sputtering. As can be seen in the Figures of the Katsube et al. reference, the apparatus for effecting the sputtering comprises a target base disposed in a vacuum chamber, an atom beam gun for irradiating a target on the target base with a neutral beam, a substrate base and a shutter for controlling the passage of sputtered particles. According to Katsube et al., argon atoms are directed into the gun 11 where they are ionized by high voltage, and the ions thus generated are accelerated in an electric field. Ion charges are then neutralized by the electronic atmosphere in the neighborhood of gun 11, thus generating high-speed neutral ion beam. (Katsube et al., Summary of Invention, Embodiment 4, Fig. 6).

Katsube et al. do not teach or suggest forming a cloud of sputtered particles as required by claim 1. Paragraph [0018] of Applicant's specification defines the cloud of sputtered particles as an increased density of thermalized sputtered particles. The thermalization occurs when the gas density in the transport region is high enough to provide intense elastic collisions between sputtered particles and atoms of residual gas. This can be achieved by increasing the gas pressure so that the mean free path of elastic collisions becomes small relative to length of transport region, providing intensive kinetic energy and momentum exchange between sputtered particles and atoms of the residual gas. These collisions create the isotropy in sputtered particle momentum and reduce its kinetic energy to a "cold" level. The thermalization reduces the energy brought by depositing particles to the film.

In the method taught by Katsube et al., there is no cloud of sputtered particles formed. In fact, Katsube et al. teach away from the necessity of such. A relatively low residual gas pressure (density) of $3x10^{-5}$ Torr (Katsube et al., Embodiment 1) to $2x10^{-4}$ Torr (Katsube et al., Experiment 4) with mean free path of elastic collisions in the range of tens of centimeters and extremely low sputter/deposition rate (Katsube et al., Fig. 8, Experiment 4) do not provide conditions for formation of a sputter particle cloud. At this gas pressure, it is believed that every particle emitted by the target would reach the substrate practically without collision. For this reason, these sputtered particles bring their original kinetic energy of several eV to the film. This energy is much higher than the energy of thermalized sputter particles. This seems to be a possible reason

why the growing films in the apparatus depicted in the Katsube et al. reference require cooling in spite of an almost negligible deposition rate (Fig. 8). Thus, the reference fails entirely to teach or suggest the formation of a cloud as required by claim 1.

Accordingly, claim 1 is not anticipated by or made obvious by the cited reference and favorable consideration of claim 1 is respectfully requested. Claims 2-5, depending directly or indirectly from claim 1, are submitted as patentable over the cited references for at least the same reasons.

Response to Rejection of Claim 6

Claim 6 is directed to a physical vapor deposition (PVD) system for deposition of dielectric materials, including low dielectric constant (low-k) materials, onto substrates during the fabrication of integrated circuits and other electronic, opto-electronic, microwave, and micro electro-mechanical (MEM) devices. More particularly, claim 6, is directed to a system for the physical vapor deposition (PVD) of dielectric material onto a substrate comprising, *inter alia*:

a sputtering target;

a low energy, large aperture ion source of energized monochromatic ions;

an ion optics system for equalizing, shaping, and directing said ions into an ion beam;

a charge transfer system for neutralization of said ion beam into a beam of neutrals;

means for directing said beam of neutrals toward the target, said beam of neutrals bombarding said target and causing said target to emit sputtered particles;

means for forming a cloud of said sputtered particles proximate said substrate; and

means for depositing said cloud of said sputtered particles onto said substrate.

Claim 6 in the application stands rejected as being obvious in view of Katsube et al. in view of the non-patented art of Shimokawa (hereinafter "Shimokawa"). Applicant respectfully traverses this rejection. Claim 6 is novel and patentable over the references of record, and particularly over Katsube et al. and Shimokawa, because the cited art does not show or suggest a system for the physical vapor deposition (PVD) of dielectric material onto a substrate comprising a charge transfer system for neutralization of said ion beam into a beam of neutrals and means for forming a cloud of said sputtered particles proximate said substrate as required by claim 6.

In paragraph 15, the Examiner states that Katsube et al. teach the limitations of claim 6 with the exception of the specifics of the ion/neutral beam source. However, as set forth above, Katsube et al. do not teach or suggest forming a cloud of sputtered particles. Shimokawa discloses a new high-power fast atom beam source. Shimokawa also does not teach or suggest the formation of a cloud of sputtered particles. Therefore, Shimokawa cannot cure the deficiencies of Katsube et al.

Accordingly, claim 6 is not anticipated by or made obvious by the cited reference and favorable consideration of claim 6 is respectfully requested. Claims 7-9, depending directly or indirectly from claim 6, are submitted as patentable over the cited references for at least the same reasons.

New Claims

Applicants have added new claims directed to subjected matter that Applicants believe is patentable over the cited art. Prompt allowance of the new claims is respectfully requested.

With reference to new claims 10 and 11, the present invention uses a very different approach of converting the ion beam into an energized monochromatic beam of neutrals. The principal difference is in utilization of a charge-transfer chamber to convert gradually fast ions into atoms along the path of beam propagation. As shown in Fig.1 the monochromatic ion beam, which has a nearly zero fast atom component in the vicinity of the either side of ion optics aperture

2 propagates along charge-transfer chamber 3, which is filled with a gas, such as rarified Ar gas. The pressure of rarified gas inside chamber 3 may not be equal to the open vacuum of the Katsube apparatus. (Katsube, Fig. 1, 6). Instead, the pressure inside of chamber provide a charge-transfer collision process between fast $Ar+$ and low energy $Ar0$ atoms. An ion energy in the range of 100-400 eV provides a preferable cross-section for charge transfer collision process between $Ar+$ and $Ar0$.

Conclusion

In view of the remarks made herein, Applicant submits that the claims presented herein are patentably distinguishable from the art applied and prompt allowance of the application is respectfully requested.

Should the Examiner determine that anything else is desirable to place this application in even better form for allowance, the Examiner is respectfully requested to contact the undersigned by telephone.

Respectfully submitted,
WEGMAN, HESSLER & VANDERBURG

By Bruce E. Peacock
Bruce E. Peacock
Reg. No. 28,457

Suite 200
6055 Rockside Woods Boulevard
Cleveland, Ohio 44131
216/642-3342

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